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Road Effects on Rodents in Saltbush Scrub Habitat

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Abstract.—**Road effects on wildlife have been well documented, although most studies have been conducted on larger species. I assessed the effects of two-lane roads on small rodents in saltbush scrub habitat in the Lokern Natural Area (LNA), Kern County, California. I and a crew of assistants live-trapped rodents during fall 2002 and 2003 on four transects established in each of three treatments: road shoulders (within 5 m of road edge), shrub habitat, and grass habitat (shrubs eliminated by past fires). Rodent abundance did not vary among treatments. However, number of species and species diversity were similar in Road and Shrub treatments, and were significantly higher compared to the Grass treatment. I caught five species of rodents in the Road and Shrub treatments, but only two species in the Grass treatment. Large, weedy non-native plants were common along road shoulders and saltbush reestablishment also was occurring along roads in previously burned areas where shrubs were absent. The resulting vegetative structure apparently created suitable conditions along road margins for shrub-affiliated rodents. This effect associated with roads may provide corridors and facilitate movements by rodents between shrub patches, which could enhance population viability for these species in the LNA.**

Key Words.—corridors; live-trapping; San Joaquin Desert; shrubs; species diversity

Introduction

Numerous investigations have been conducted on the effects of roads on wildlife populations (reviews in Forman et al. 2003; Coffin 2007; Taylor and Goldingay 2010; van der Ree et al. 2011). Many of these investigations documented adverse impacts from roads such as vehicle strikes, habitat loss and fragmentation, disturbance, and deposition of contaminants. However, adverse impacts are not universal. In a review of 79 studies involving 161 species or species groups, Fahrig and Rytwinski (2009) found that negative effects were detected on 114 occasions, no effects were detected on 56 occasions, and positive effects were detected on 22 occasions. In general, they found that amphibians and reptiles were adversely impacted, birds were adversely or not affected, small mammals exhibited no or positive effects, medium-sized mammals exhibited no or negative effects, and large mammals usually were adversely affected. Thus, road effects vary with species and circumstances. I sampled rodents as part of an investigation of road effects on endangered San Joaquin kit foxes (*Vulpes macrotis mutica*) in the Lokern Natural Area (LNA) in western Kern County, California (Cypher et al. 2009). I retrospectively analyzed these data to determine whether proximity to roads affected rodent abundance and community composition.

Methods

The LNA is located in the San Joaquin Desert 45 km west of the city of Bakersfield and comprised a mosaic of private and public lands. The terrain on the study area was flat to gently rolling and elevation was approximately 100 m. The regional climate was Mediterranean in nature and was characterized by hot, dry summers, and cool, wet winters with frequent fog. Mean maximum and minimum temperatures were 35° C and 18° C, respectively, in summer, and 17° C and 5° C, respectively, in winter. Annual precipitation averaged ca. 15 cm and occurred primarily as rain falling between October and April (National Oceanic and Atmospheric Administration 1996).

The vegetation community in the LNA was characterized as Lower Sonoran Grassland (Twisselmann 1967) or Allscale Series (Sawyer and Keeler-Wolf 1995). The community consisted of arid shrublands with a sometimes dense herbaceous cover dominated by nonnative grasses and forbs. Desert Saltbush (*Atriplex polycarpa*) and Spiny Saltbush (*A. spinifera*) were the dominant shrubs and Cheesebush (*Hymenoclea salsola*) and Bladderpod (*Isomeris arborea*) also were common. These shrubs are not fire-adapted and large portions of the study area were devoid of shrubs due to repeated wildfires. Periodic grazing by cattle and sheep in the LNA likely inhibited shrub re-establishment in these areas. Ground cover consisted primarily of annual grasses and forbs and was dominated by Red Brome (*Bromus rubens madritensis*) and Red-stemmed Filaree (*Erodium cicutarium*).

Two state highways (State Routes 58 and 33) and a county road (Lokern Road) traversed the study site. These were all two-lane roads with traffic volumes that varied from 800 vehicles to 1,500 vehicles per day (California Department of Transportation 2003) with most traffic occurring during daylight hours. I and a crew of assistants live-trapped rodents on transects in three treatments: Road, Shrub, and Grass. Road treatments included the areas within an approximately 10-m wide strip along each side of each road. Barbed-wire fences (three or four strands) defined outer boundaries of the Road treatments. Shrub treatments included areas with intact shrub communities. Grass treatments included ar-

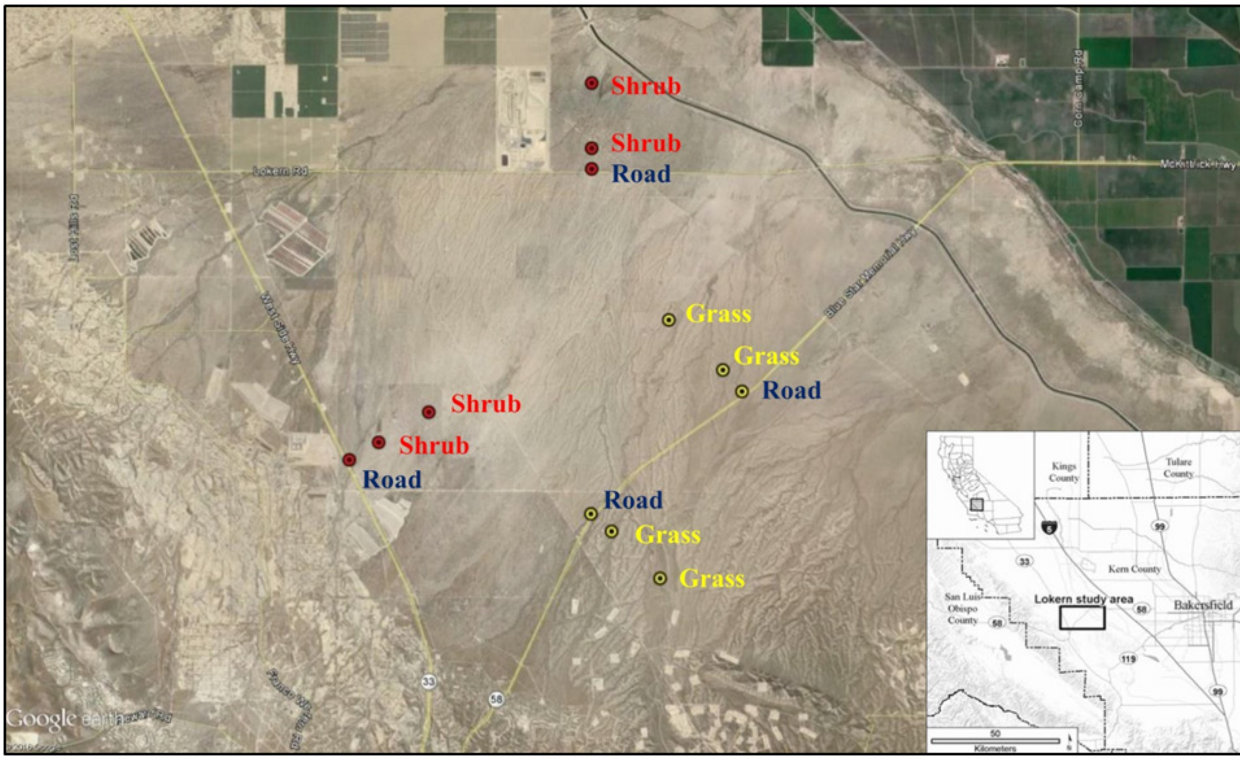

FIGURE 1. Locations of rodent live-trapping transects in the Lokern Natural Area, Kern County, California.

eas with no or only sparse, very widely scattered small shrubs due to past fires. I established four Road transects along the shoulders of the two-lane roads and each transect was located approximately 5 m from the edge of the road pavement (Fig. 1). I also established four transects each in the Shrub and Grass treatments. In each of these treatments, two transects were located 500 m from the nearest road and two were located 1500 m from the nearest road. Each transect consisted of 25 Sherman traps (8 × 8 × 30 cm) spaced 10 m apart. Traps were opened and baited traps with commercial birdseed in late afternoon a paper towel was placed in each trap to provide bedding material. I and my crew checked traps beginning approximately 2 h after sunset for four consecutive nights during each trapping session. For each captured rodent, species, sex, and mass were recorded, and each individual was marked ventrally with a non-toxic marking pen.

I and my crew trapped rodents in November of 2002 and 2003. For each year, I calculated the number of unique individuals, number of species, and species diversity for each transect. I used the Shannon diversity index (H') to determine species diversity:

$$H' = (N \log N - \sum n_i \log n_i)/N$$

where N is the total number of individuals and n_i is the number of individuals of species i (Brower and Zar 1984). I used a one-way analysis of covariance with year as a covariate, and a Student-Newman-Keuls multiple comparison test to compare means among the three treatments. I considered results significant if $P \leq 0.05$.

RESULTS

Over the two trapping sessions, I captured 507 individual rodents representing six species (Fig. 2). These included 297 Short-nosed Kangaroo Rats (*Dipodomys nitratoides brevinasus*), 146 Heermann's Kangaroo Rats (*D. heermanni*), three Giant Kangaroo Rats (*D. ingens*), 42 North American Deer Mice (*Peromyscus maniculatus*), 14 Tulare Grasshopper Mice (*Onychomys torridus tularensis*), and six California Pocket Mice (*Chaetodipus californicus*). The mean number of individuals captured was similar among the Road, Shrub, and Grass treatments ($F_{2,20} = 0.47$, $P = 0.632$; Table 1). However, species composition differed among treatments (Fig. 2). I captured significantly more species in the Road and

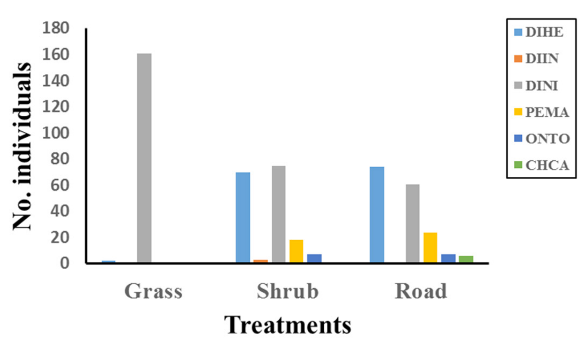

FIGURE 2. Number of individual rodents captured in Road, Shrub, and Grass treatment areas in the Lokern Natural Area, Kern County, California, November 2002 and 2003.

Figure 3. Two images of dense vegetation along roads in the Lokern Natural Area, Kern County, California. (Photographed by Brian Cypher)

Shrub treatments ($F_{2,20}$ = 17.11, P < 0.001; Table 1). I captured four species in each of these treatments plus an additional species exclusive to each of the treatments; Giant Kangaroo Rats were caught only in the Shrub treatment and California Pocket Mice were caught only in the Road treatment. In the Grass treatment, I captured only Short-nosed Kangaroo Rats except for one Heermann's Kangaroo Rat captured on each of two Grass transects in 2002. Consequently, mean species diversities were significantly higher on Road and Shrub treatments than Grass treatments ($F_{2,20}$ = 25.75, P < 0.001).

Discussion

The intact saltbush scrub community in the LNA supports a diversity of rodent species. Conversely, in areas where disturbance has eliminated most or all shrubs, the rodent community appears reduced almost to a single species. The low rodent diversity observed in the Grass treatment probably was attributable to the reduction in ecological complexity associated with the fire-induced absence of shrubs. The vegetation structure in the Grass treatment generally was lower and sparser compared to that in the Shrub treatment.

The similarity in rodent community attributes between the Road and Shrub treatments suggests that the two-lane roads in the study area were not having a detectable effect on rodents. The vegetation structure along the roads (Fig. 3) generally resembled that in the Shrub treatment areas. Road-side vegetation likely was influenced by the presence of the roads. In particular, large weedy non-native species commonly occurred along roads in the study area and included Sour Clover (*Melilotus indicus*), Shortpod Mustard (*Hirschfeldia incana*), Tocalote (*Centaurea melitensis*), and Russian thistle (*Salsola* spp.). Proliferation of non-native plants along roads is common (Forman et al. 2003; Hansen and Clevenger 2005). These species likely benefitted from the disturbance along road edges, precipitation runoff and accumulation, and possibly nitrogen deposition from vehicle emissions (Angold 1997; Forman et al. 2003). Furthermore, where roads crossed though areas without shrubs (e.g., Grass treatments), saltbush reestablishment was occurring along the road shoulders, possibly due to the increased moisture from runoff and also the exclusion of grazers by the fences along the roads. The presence of the non-native species and some saltbush apparently increased ecological complexity sufficiently along roads to support rodent communities similar to those found in shrub habitat.

The extensive areas without shrubs in effect caused fragmentation of the native saltbush scrub community in the LNA. The abundance and diversity of rodents in the Road treatments indicated that the habitat conditions in these areas were suitable and in fact, comparable to conditions in intact shrub habitat. Two of the Road transects

Table 1. Means (SE) for number of rodents captured, number of species, and species diversity on transects (n = number of transects) in Road, Shrub, and Grass treatment areas in the Lokern Natural Area, Kern County, California, November 2002 and 2003. Means with different letters are significantly different ($P \leq 0.05$).

	Treatment		
	Road (n = 8)	Shrub (n = 8)	Grass (n = 8)
Number of Individuals	21.5 ^{A}	21.5 ^{A}	20.4 ^{A}
	(2.0)	(3.7)	(3.4)
Number of species	3.75 ^{A}	3.13 ^{A}	1.25 ^{B}
	(0.16)	(0.48)	(0.16)
Diversity (H')	0.98 ^{A}	0.79 ^{A}	0.46 ^{B}
	(0.05)	(0.16)	(0.03)

were in areas where roads crossed through areas without shrubs, and these transects were approximately 400 m and 750 m, respectively, from the nearest shrub habitat. However, rodent abundance and diversity was similar between these transects and the two Road transects in areas where roads crossed areas with shrubs. Consequently, the road margins potentially can function as corridors and provide connectivity between patches of shrub habitat. In essence, this constitutes a positive ecological effect associated with roads, at least with regard to rodent communities. Movements between shrub patches would facilitate demographic and genetic exchange. This might particularly benefit rare species such as the Tulare Grasshopper Mouse (California Species of Special Concern) that primarily occurred in shrub habitat and that have been impacted by habitat loss and fragmentation (U.S. Fish and Wildlife Service 1998).

Elsewhere, rodents also have been found to benefit from altered vegetation structure along road margins (Adams and Geis 1983; Woodward 1990) and to use these margins as movement corridors. Botta's Pocket Gophers (*Thomomys bottae*; Huey 1941) and Meadow Voles (*Microtus pennsylvanicus*; Getz et al. 1978) have even used road margin corridors to extend their range and colonize new areas. Roads clearly can act as significant barriers for perpendicular (across road) movements by rodents (Oxley et al 1974; Garland and Bradley 1984; Mader 1984; McGregor et al. 2008) and thereby contribute to habitat fragmentation, even resulting in genetic subdivision between populations on opposite sides of a road (Gerlach and Musolf 2000). However, in certain situations roads may facilitate lateral (along road) movements and provide connectivity between habitat fragments, and this could enhance local population viability for species.

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